Final Technical Report for Grant N00014-89-J-2042

Here are copies of papers I've written with the support of the NRL Grant No. N00014-89-J-2042. I would like these to serve as a final technical report.

I will summarize briefly here. The first paper, "Simulations of rough interface scattering," finished off work started at NRL using the Cray. At NRL, I simulated rough surface scattering by solving for the amplitudes of scattered plane waves using the Rayleigh-Fourier method. What was new here was the treatment of fluid-solid interfaces, for which scattering shows a number of interesting features not present for scattering from pressure release surfaces. These include abrupt changes when critical angles are encountered and a small rise in backscatter direction when the incident field arrives at the Rayleigh angle for the flat surface. The latter effect is still not fully understood, but I don't think it is a multiple scattering effect.

The paper "Boundary effects in Quantum Mechanics," appeared in American Journal of Physics **59** p.937 (1991). I happened to come across another paper there which as part of a discussion of solitons, needed a result on how eigenvalues are affected by boundary perturbations. It seemed to me that my work on Dashen's formula concerning manifestly reciprocal scattering amplitudes would give the solution quite easily.

The paper "Rough interface scattering without plane waves" SPIE **1558** 1991 p.191-201, was the result of an invited (by John DeSanto) talk given at their San Diego meeting. The emphasis there was to formulate a variational principle from which Dashen's manifestly reciprocal results could be generalized to non-plane wave incident fields. I was able to use this to derive a simple formula for backscattering by a point source in the small-slope approximation. It was not for want of effort that I was unable to generalize the result to bi-static scattering.

A similar paper, "The small-slope approximation for monostatic scattering," has recently been submitted and accepted by JASA and contains more details of the derivation in the SPIE paper.

"Renormalization of propagation in a waveguide with rough boundaries," has been accepted by JASA. The referree recommended publication with some changes, which have been made. This paper holds the most promise for future work. Since there are now some pretty good approximations for scattering of plane waves in half- spaces bounded by rough interfaces, I thought it time to ask how these results could be used in a waveguide.

By using a version of the method of smooth perturbations, not on the bounding surfaces but rather on an imaginary plane running down the center of the waveguide, I was able to show that the mean Green's function in the waveguide is of the same form as in the flat-surface waveguide but using renormalized reflection coefficients. It turns out that the reflection coefficients are not only renormalized by the roughness on one surface, but also by energy returning from the other bounding surface, even if that surface is flat. I am planing to write another paper showing how normal modes are affected by the roughness. I have already been able to rederive the results of Bass and Fuks for the attenuation of normal modes in the case of small roughness.

Finally, I have written a paper "Completeness of scattering states for rough interfaces." I am not sure where to publish this; it seems too mathematical for JASA and I have submitted it to Annals of Physics. I was able to show that if the Rayleigh hypothesis holds, then the scattering states are complete. This has been shown earlier for elastic waves in a solid with a flat boundary on a vacuum using all the details of the reflection coefficients. I was able to show completeness for rough boundaries using reciprocity, energy conservation, and causality. I was really trying to discover the role of surface waves in construction of Green's functions. I concluded that they needn't be accounted for explicitly since they are implicit in the scattering amplitudes.

Most of this work has also been reported at Acoustical Society meetings.

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